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TECHNOLOGY FOR SS FREEDOM EVOLUTION - A WORKSHOP

EVA / MANNED SYSTEMS WORKSHOP
CHAIRMAN - BRUCE WEBBON, PhD.

SIMPLIFIED AID FOR CREW RESCUE (SAFR)

16-19 Jan. 1990

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AGENDA

- Crew Emergency Rescue Program
- Functional Description
- Operational Description
- I/F's With Other Subsystems/Elements
- SAFR Characteristics
- Potential Resource Requirements
- Logistics, Repair & Resupply
- Potential Performance Improvements
- Automation Impact
- Summary & Conclusions

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CREW EMERGENCY RESCUE SYSTEM PROGRAM

NASA-JSC has requested a two part study be undertaken for SS Freedom Work Package 2 which will subsequently develop a point design concept(s) for a Crew Emergency Rescue System (CERS). This study is the responsibility of McDonnell Douglas (Work Package 2 prime) assisted by Lockheed (subcontractor to MDAC). This basic program has, and is addressing the potential of an EVA crewperson or equipment item becoming detached from the SS Freedom with the objective of rescuing the individual or retrieving the adrift equipment item. The currently on-going study is composed of two parts:

- Part I - Delineation of rescue/retrieval requirements, identification of alternative hardware concepts, and conduct of trades to down select the concepts to a managable number for study in the next phase.
- Part II - Detailed definition of the concept(s) selected, subsystem delineation and trade-offs, development of a point design, preparation of a top level specification, generation of basic program costs, preparation of a candidate precursor prototype flight experiment on the Orbiter, and development of a DDT&E schedule.

Part I of the study has been completed and effort is well underway for Part II. Both existing and 'leading edge' technology is being examined as part of the effort, thus, the applicability to this workshop.

CREW EMERGENCY RESCUE SYSTEM PROGRAM

A. NASA-JSC Directed Study On EVA Crew Rescue & Equipment Item Retireval

- Work Pkg. 2 - McDonnell Douglas & Lockheed

B. Two Part Study

- Part I Complete - Reqts., Trades, Concept Selection
- Part II Underway - Point Design Evolution

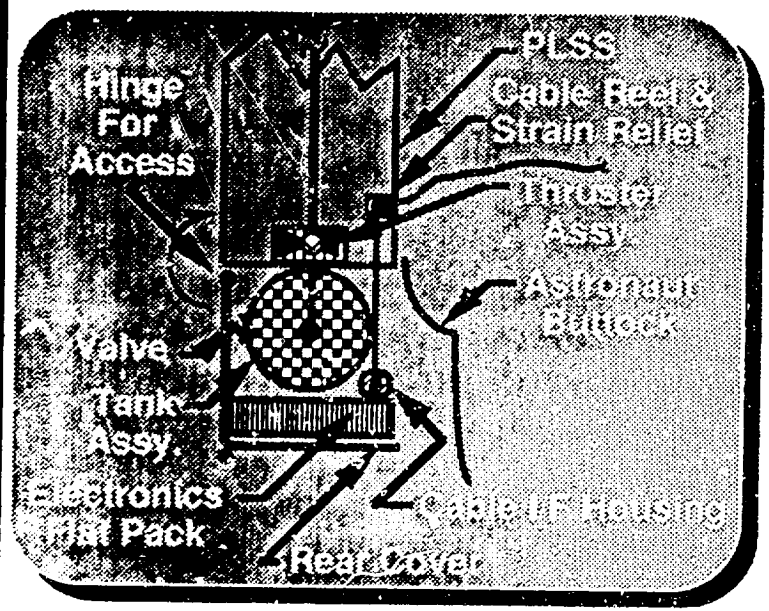
C. Two Primary Concepts Being Pursued

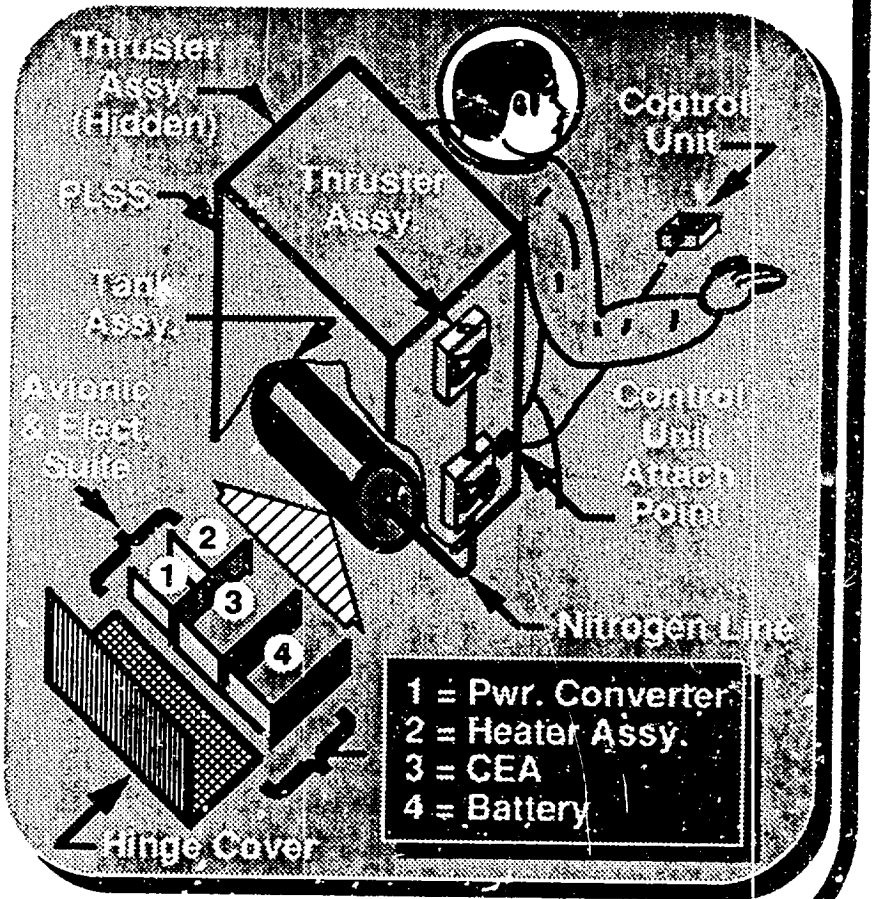
- Autonomous Free Fyler - MDAC
- Simplified Crew Aid For Rescue (SAFR) - Lockheed

FUNCTIONAL DESCRIPTION

As the CERS program evolved in Part I of the study, two substantially different concepts emerged for subsequent study: (1) An autonomous free flyer (MDAC); and (2) Simplified Aid For Rescue [SAFR] (Lockheed). This briefing addresses the SAFR concept (shown on the facing page). The SAFR is a modular system attached to the Extravehicular Mobility Unit (EMU) and worn during the entire EVA sortie. It utilizes multiple thrusters for propulsive capability with Nitrogen as the basic fuel. The thrusters are nounted on the sides of the Personal Life Support System (PLSS) 'backpack' while the tank and avionics suite is mounted beneath the PLSS to min mize any encumbrance to the EVA crewperson. The avionics suite provides flight control capability with a 'hand controller' as the EVA crewperson interface device for nulling out tumble and for control of yaw and pitch. A battery provides power to the avionics and heaters are provided for temperature control of the avionics suite, hand controller, and tankage assembly. The modularity of the SAFR design allows for installation on either the NSTS or SS Freedom EMU's.

FUNCTIONAL DESCRIPTION



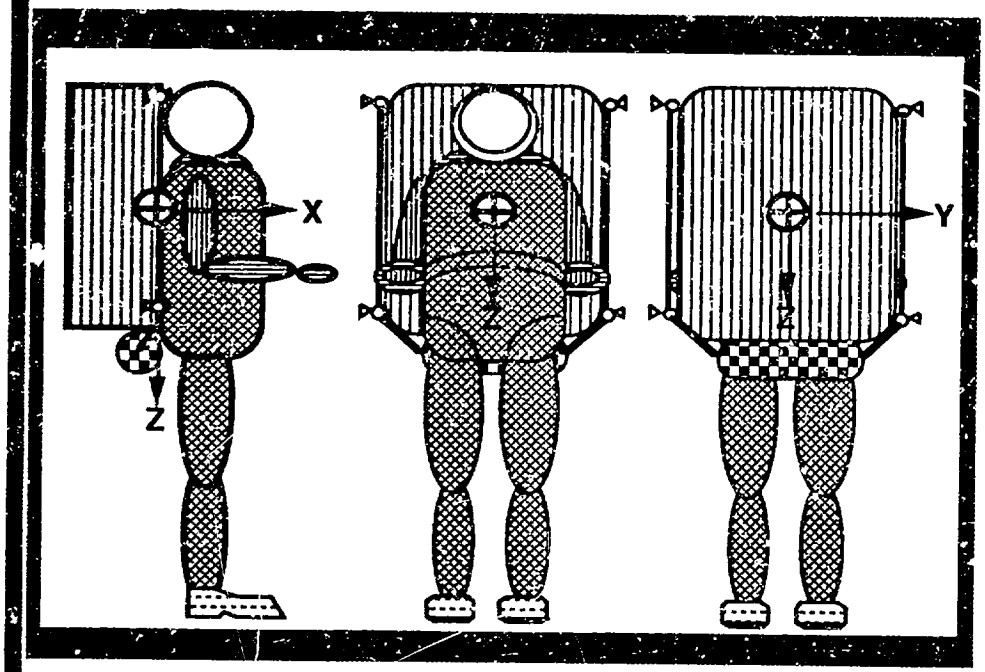


- Propulsive Approach
- Multi-Thrusters
- Min. Control System
- Min. Encumbrance
- Self Contained / Modular
- Light Wt. & Min. Volume
- Nitrogen Propellant

OPERATIONAL DESCRIPTION

The SAFR concept is, simply stated, a 'lifevest' used for the emergency return of an adrift EVA crewperson to the orbiting element from which he or she became detached. As such, it is a minimum system with no frills and is in no way intended as a replacement for the much more versital and capable Manned Maneuvering Unit (MMU). Should the EVA crewperson become detached from an orbital element (e.g., SS Freedom) the inital task would be to null the tumble or spin via an automatic mode built into the avionics. The EVA crewperson would then use the hand-controller to slowly yaw or pitch him or herself to a position wherein the orbital element is within their view by use of nitorgen fueled propulsive capability. The individual then translates via line-of-sight (LOS) at a slow rate, e.g., less than 5'/sec., and, if neccessary, makes a final adjustment burn prior to final 'soft contact' with the orbital element. The SAFR is pre-checked out in the airlock, and is serviced therein as required, including nitrogen gas resupply if needed. The thrusters are positioned and configured such that if a particular nozzle valve or regulator fails, there is only a 'graceful degradation' to the system and sufficient capability exists for a degraded mode return. This SAFR currently is being designed for a conscious and system participative EVA crewperson, although future studies may examine an autonomous return mode for a potentially disabled individual. SAFR is planned for use on either the NSTS or SS Freedom EMU's and, therefore, can be operated out of the Shuttle or SS Freedom airlocks.

OPERATIONAL DESCRIPTION



- 3 Axis Single Mode Ops
- Line-Of-Sight Pointing
- Range ~ 1000 Ft.
- Tumble Null - Auto Mode
- Laser Gyro Stabilization
- Use - NSTS / SSF EMU's
- Conscious Crewperson
- Airlock C/O & Service
- Hand Controller Ops
- Multi-Thrust Utilization

I/F'S WITH OTHER SUBSYSTEMS / ELEMENTS

The facing page indicates the major interfaces the SAFR system will have with presently defined orbiting elements, e.g., SS Freedom or the NSTS. As shown, SAFR intefaces to the EMU in 7 locations relative to attachment. An option is an I/F with the EMU comm in the event that autonomous operations might be achievable. The attachments are designed to be modularly and multi-positionable to assure flexibility in attachment to the EMU. When used with the SS Freedom over the duration of the program, it is planned to provide simple C/O and servicing of the SAFR within the airlock and to use the planned EMU checkout and servicing equipment system for that function. Nitrogen will be acquired from the indigenous SS Freedom supply for tank refill as required. The SAFR design is purposely compact to assure minimum protuberances and envelope profile to preclude any encumbrance when egressing or ingressing from or to the Airlock, or when conducting any EVA task.

I/F'S WITH OTHER SUBSYSTEMS / ELEMENTS

EXTRAVEHICULAR MOBILITY UNITS

- NSTS EMU
- SS Freedom EMU

- Personal Life Support Sys
  - Δ Structure - 7 Locations
    - Thrusters - 4 I/F's
    - Avionics - 2 I/F's
    - Hand Controller - 1 I/F
  - Δ Comm (Option)
    - EMU Radio - 1 I/F

AIRLOCKS

- NSTS - Space Shuttle
- Space Station Freedom

- Hatch Pass-Through
- Nitrogen Supply
- CASES
  - Δ Sys Checkout
  - Δ Battery Recharge
  - Δ Comm Link Check
  - Δ Gyro Initialization
  - Δ Nitrogen Pressure C/O
  - Δ Fault Isolation - Maint.

SAFR CHARACTERISTICS

The facing page presents a simplified list of the basic system hardware for SAFR. As evidenced by the short list, the system is, from program on-set, planned to be a minimum capability, simple approach, based on evolution of technology (MMU) already successfully flown on the Orbiter. This approach is specfically directed to minimizing any Crew skills required to operate the system and to reduce ground simulation to a bare minimum. The current design goal relative to total mass is ~ 45 lbs (dry weight). A weight of 4.5 lbs. is being carried as a management contingency reserve at this time. Where possible existing hardware and technology will be used. Areas wherein new or 'leading edge' technology may be examined include, but are not limited to: (1) Batteries; (2) Tanks, and (3) Small gyros and accelerometers. The currently identified major driver appears to be power (avionics, heater needs, and thruster operations). Thus, the desire to closely examine the current battery technology state-of-the-art.

SAFR CHARACTERISTICS

HARDWARE	QUAN.
1. Thruster Assy.	4
2. GN_2 Tank	1
3. Pressure Regulator	1
4. Toggle Valve	1
5. Isolation Valve	1
6. Quick Disconnect	1
7. Pressure Gague	1
8. Heater Strips	6
9. Prop. Lines/Fittings	4
10. Battery	1
11. Rate Gyro Cluster	1
12. Control Electronics Assy.	1
13. Power Converter	1
14. Housing	1
15. Cables & Attach Fittings	Misc.
16. Protective 'Cover'	1
17. Hand Controller Unit	1

MASS (Lbs.)

- Design Goal = 45
- Management Contingency = 4.5

Total = 49.5

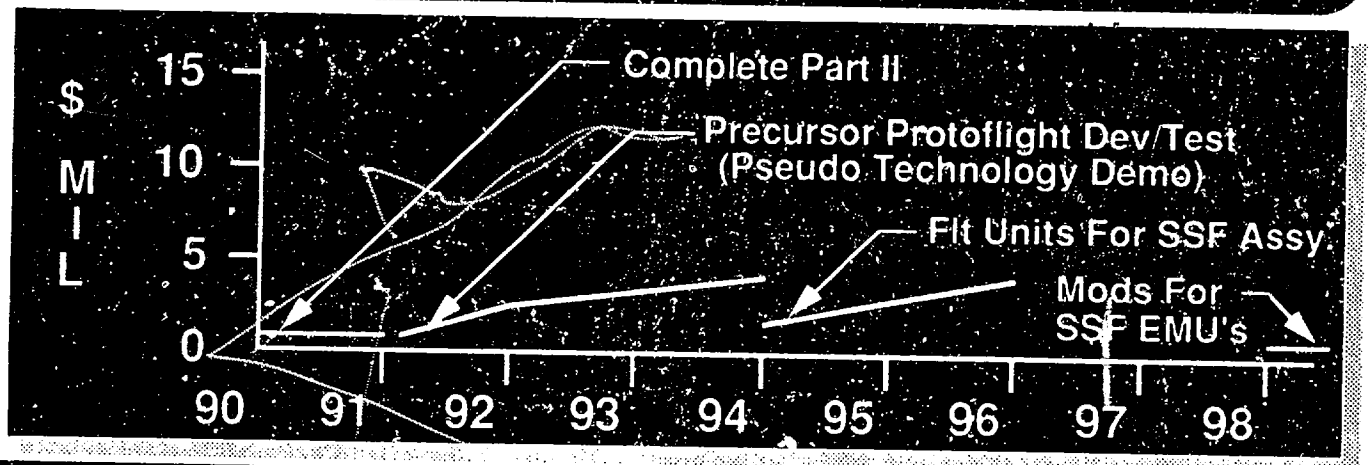
POTENTIAL RESOURCE REQUIREMENTS

The facing page presents the current approach relative to the development of SAFR. Presently, consideration is being given to the possibility of a Shuttle flown precursor experiment which would employ a SAFR protoflight unit. Such a flight would permit the evaluation of the SAFR approach, and perhaps simultaneous comparison with the GEMINI era hand-held maneuvering unit. This approach would permit early examination and assessment of the SAFR concept and associated technology. Current resource requirements are portrayed on the opposite page and indicate the very low cost profile envisioned for the program. By keeping the system very simple (no bells and whistles), such an effort as this may be feasible in the current severe economic environment, yet provide a very real need to support crew safety.

POTENTIAL RESOURCE REQUIREMENTS

CURRENT PHILOSOPHY

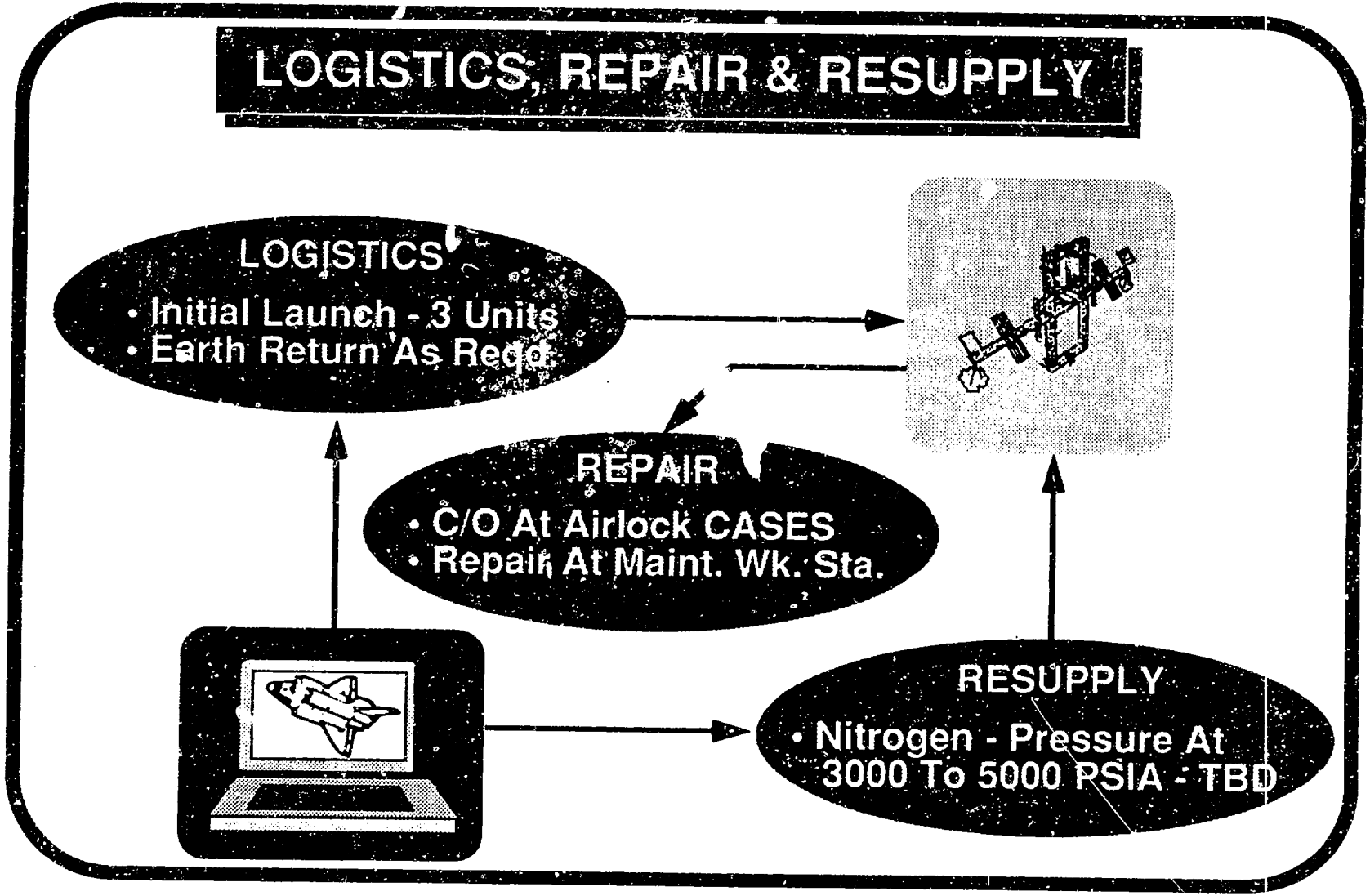
- Complete Part II Conceptual Design Study For NASA
- Consider Pre-Cursor Shuttle Flight Demonstration
- Implement SAFR For SS Freedom
  - Δ Develop For Initial SS Freedom Build-Up (Employ On NSTS EMU)
  - Δ Modularly Change Over To SS Freedom EMU For Ops



LOGISTICS, REPAIR & RESUPPLY

The SAFR system has, purposely, been designed as a very simple hardware element. As such, servicing, repair and logistics has been, from the begining, as a minimum support need. The basic SAFR hardware (3shipsets) is planned for launch via the NSTS for initial supply to the SS Freedom. Since the avionics suite, thruster assemblies are modular, some on-orbit servicing is quite feasible using the 3rd shipset item as both a backup unit and as a 'real-time' spare. Should any subsystem element of SAFR need replacement on-orbit via logistics resupply, the weight and volume would be very low. Maintenance or repair of SAFR can be accomplished easily at the SS Freedom Maintenance Work Station once the tank had been removed or nitrogen externally vented while in the Airlock. The Airlock also serves as a SS Freedom candidate facility for nitrogen resupply although some question remains as to the final selected pressure.

LOGISTICS, REPAIR & RESUPPLY



POTENTIAL PERFORMANCE IMPROVEMENTS

The facing page indicates that a crew aid such as SAFR with its explicit objective (EVA crew rescue) has not been previously developed. How0 ever, it is patently obvious that the MMU could very readily perform that function as part if its extensive capability. Historically, the Gemini era Hand-Held Maneuvering Unit comes to mind relative to an EVA device used a few times for examining man's capability for maneuvering on-orbit although the astronaut was tethered. For purposes of comparision with the HHMU, the potential enhancements brought about by the SAFR concept are indicated on the opposite page. These enhancements, therefore, could be considered technology upgrades. However, the HHMU still remains a potential candidate for the rescue function until such time that it is decided that its operation may be too complex, that consumate skill level requirements may be excessive, and/or that training/simulation investments are too great.

POTENTIAL PERFORMANCE IMPROVEMENTS

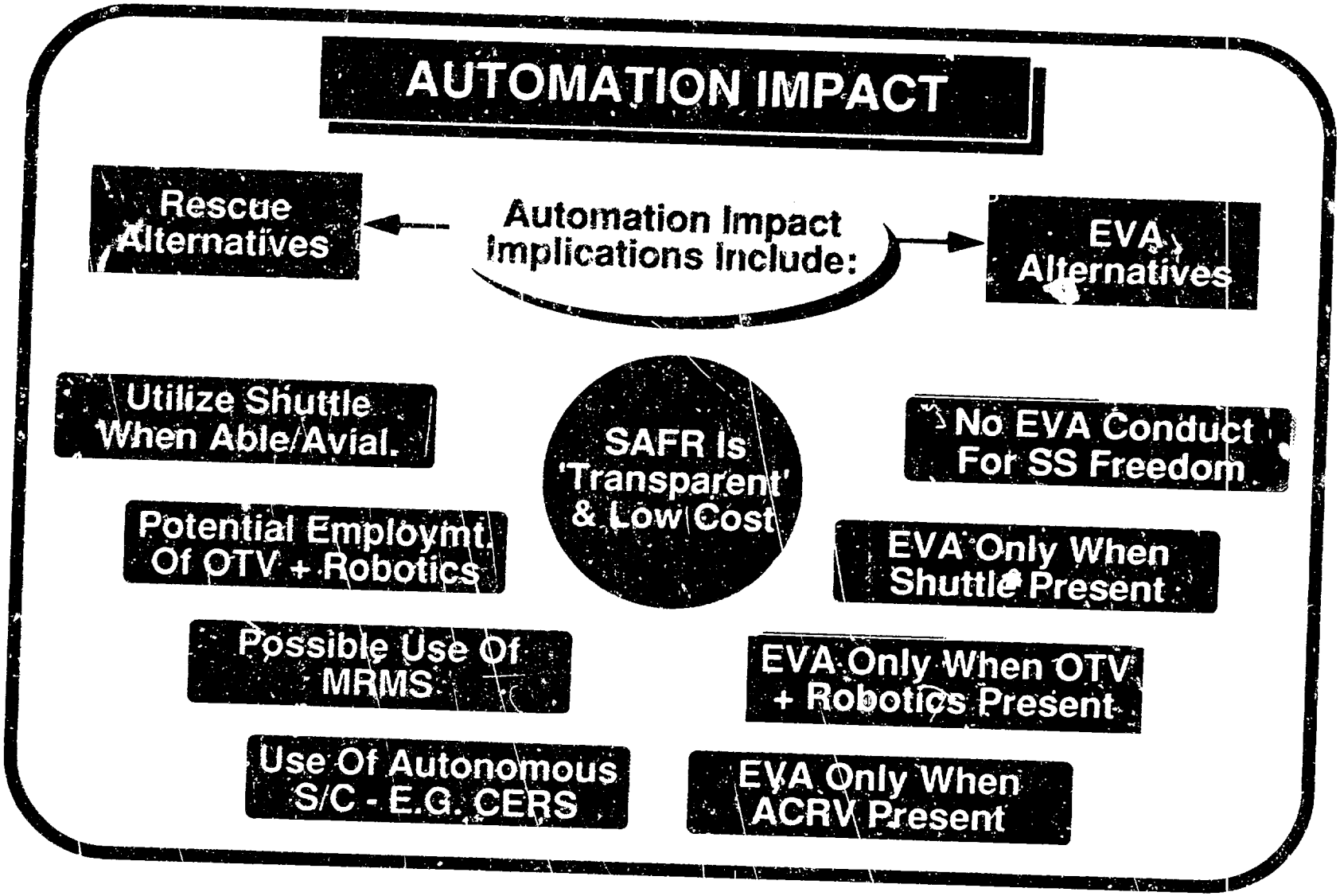
An Aid Such As SAFR Has Not Been Specifically Developed Before. However, The Manned Maneuvering Unit Certainly Could Play Such A Role, And Perhaps The Gemini Era Hand Held Maneuvering Unit(HHMU) Could Be Used For This Task.

SAFR Is Not Intended To Replace The MMU. Thus, Potential Performance Enhancement Over The HHMU Would Be:

- Increased Range
- Simplified Operations
- Much Lesser Training & Simulation
- Increased Control Performance
- Multi-Uses Prior To Refurbishmt.
- Modularity
- On-Orbit Servicing
- Graceful Failure Degradation

AUTOMATION IMPACT

The current elements of the SS Freedom automation program are not yet, at least to the author, fully clear. Accordingly, to define the specific automation impacts on SAFR is difficult at this time. However, the facing page indicates typical impacts if, for example, EVA were eliminated from the program or conducted only at certain times then, obviously SAFR need not be implemented. The premise being that EVA had been eliminated or conducted only at a time when some other rescue technique were available. Also shown on the chart are alternatives to SAFR. These have been assessed resulting in the autonomous S/C (CERS) concept leading the alternatives (and other less viable candidates) based on its extensive capability for conduct both the rescue and retrieval mission, and particularly since it is berthed to the SS Freedom at all times. However, until a reasonably complete snapshot is available of the overal autonomy program, impacts on SAFR and CERS are unclear. Further, with the low DDT&E outlay, rapid implementation schedule potential for the SAFR, and its basic transparency, it remains a very viable method for EVA crew rescue. Finally, it is not envisioned that automation will totally eliminate the need for EVA particularly in SS Freedom assembly, for certain EV contingencies, nor for complex one-of-a-kind extravehicular functions.


AUTOMATION IMPACT
Rescue Alternatives
Automation Impact Implications Include:
EVA Alternatives
Utilize Shuttle When Able/Avial.
SAFR Is 'Transparent' & Low Cost
No EVA Conduct For SS Freedom
Potential Employmt. Of OTV + Robotics
EVA Only When Shuttle Present
Possible Use Of MRMS
EVA Only When OTV + Robotics Present
Use Of Autonomous S/C - E.G. CERS
EVA Only When ACRV Present

SUMMARY & CONCLUSIONS

1. A Simplified Aid For Rescue (SAFR) Has Been Described & Operations/Functions Presented
2. SAFR's Use Is Essentially That Of A 'Life Jacket'

A. SAFR Represents No Technology Risk

B. 'Cutting Edge' Technology Can Be Used

C. SAFR Is A Low Cost Technology Development Item With Future Spin-Offs

D. SAFR Is A Multi-Program Applicable Technology

E. SAFR Addresses A Major NASA Thrust - Crew Safety

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